

Differences in *Tibialis Anterior* Muscle Activity in the Lower Limb During the *Lunge* Phase in Female Fencers With and Without a History of Injury

Satroda Muryanto^{1*}, Hikmatul Laili Nur'aini²

^{1,2}Program Studi S1 Fisioterapi, STIKes Bakti Utama Pati, Indonesia

Email: satroda@stikesbup.ac.id

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ABSTRACT

Introduction: Fencing is a sport involving explosive movements that carry a high risk of injury to the lower limbs, particularly when performing *lunges*. Injuries can affect the activation patterns of muscles involved in stabilisation and movement control. This study aimed to investigate differences in *tibialis anterior* muscle activity in the lower leg during the *lunge* phase in female fencers with and without a history of injury. **Methods:** This study employed a quantitative observational approach with a cross-sectional design. The study subjects comprised 12 female fencers divided into two groups: those with a history of injury and those without. Muscle activity was measured using *surface electromyography (sEMG)* of the *tibialis anterior* muscle during the *lunge* phase. Data were analysed using the Shapiro-Wilk test for normality and the Mann-Whitney test to determine differences between groups. **Results:** The results showed that *tibialis anterior* muscle activity in the group with a history of injury was lower (141.91 ± 30.21) compared to the group without a history of injury (251.29 ± 88.50). Statistical analysis revealed a significant difference between the two groups ($p = 0.028$). These findings suggest that a history of injury influences the activation of the *tibialis anterior* muscle in female fencers. **Conclusion:** In conclusion, there is a difference in *tibialis anterior* muscle activity between female fencers with and without a history of injury during the *lunge* phase.

Keywords: muscle activity, fencing, lunge, history of injury, *tibialis anterior*.

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INTRODUCTION

According to Ismail's 2017 study, fencing is a combat sport in which two competitors fight by making contact with their opponent (*et al.*, 2017) . Fencers use a specialised sword to compete in order to win a match(Ciaccioni *et al.*, 2024) . Fencing is one of the most popular *combat sports* in the world; it is a duelling sport that demands speed, precision and a high level of coordination in every offensive and defensive manoeuvre. In recent years, the development of this sport has shown an upward trend in various countries, both in terms of the number of athletes and the intensity of competition. Harmer (2020) reports that the increase in fencer participation has been accompanied by greater physical demands and greater complexity in the movements that must be mastered. One of the key components of fencing performance is footwork,

particularly the *lunge*, which serves as a fundamental technique for executing effective attacks. Ugbolue *et al.* (2021) explain that *the lunge* involves the coordination of various body segments and the synergistic activation of the lower limb muscles to produce stability and efficiency of movement.

As performance demands increase, the risk of injury among fencers has also become a major concern, particularly in the lower extremities. Globally, injuries to the lower limbs are reported to account for a higher proportion than injuries to other parts of the body, with injuries to muscle and ligament tissue predominating (Harmer, 2020) . According to *the International Olympic Committee*, fencing is one of the sports with a high risk of injury. In line with research conducted by Harmer in 2020, it was revealed that 72.4 per cent of injuries among fencers tend to



occur in the lower limbs. On average, injuries occur to ligaments (40.8 per cent) and muscles (20.1 per cent). The most common specific injury is to the lower leg, accounting for 25.3 per cent of all lower limb injuries (Harmer, 2020). The mechanisms of injury are often associated with explosive and repetitive movements, particularly during the landing phase of a *lunge*, which places significant mechanical stress on the joints and muscles (Ugbolue et al., 2021). These conditions have the potential to cause muscle fatigue, balance disturbances, and an increased risk of recurrent injury if not counterbalanced by good *neuromuscular* control (Kurniawan et al., 2023).

At both national and local levels, lower limb injuries amongst fencers remain a common issue, particularly amongst athletes who train at a high frequency. One of the muscles that plays a key role in maintaining ankle stability during a *lunge* is the *tibialis anterior muscle*. This muscle is involved in dorsiflexion and helps control foot position during the contact phase with the ground, thereby contributing to the stability and accuracy of movement (Gholipour et al., 2008). However, in athletes with a history of injury, the function of this muscle may be altered due to *neuromuscular* disorders or previous *microtrauma* (Franco et al., 2021). These changes have the potential to lead to reduced motor control, muscle imbalance and an increased risk of further injury (Alkjær et al., 2020).

Muscle activity can be assessed objectively using *surface electromyography* (sEMG), which is capable of depicting patterns of muscle activation during movement. Gohel and Mehendale (2020) state that sEMG can be used to assess *neuromuscular* activity and function during movement. Nevertheless, research on muscle activity in fencing still tends to focus predominantly on large muscles such as the *quadriceps* and *gastrocnemius*, whilst information regarding distal muscle activity—particularly that of the *tibialis anterior muscle*—in female fencers with a history of injury remains limited (Borysiuk et al., 2022). This lack of information constitutes a *research gap*, as the *tibialis anterior muscle* plays a role in movement control and ankle stability during dynamic activities, including when performing *lunges*.

Furthermore, the biomechanical and *neuromuscular* characteristics of female athletes may differ from those of male athletes; consequently, findings from male populations cannot be directly generalised to female athletes. Consequently, the novelty of this study lies in the analysis of differences in *tibialis anterior muscle* activity during the *lunge* phase in female fencers with and without a history of injury, using the Noraxon MR3 3.8.30 sEMG system. It is hoped that this approach will provide more specific information regarding the characteristics of distal muscle activation in female fencers based on their injury history and serve as a basis for consideration in the evaluation and development of sports physiotherapy programmes.

The aim of this study was to investigate differences in *tibialis anterior muscle* activity in the lower leg during the *lunge* phase in female fencers with and without a history of injury, using *surface electromyography* (sEMG) with the Noraxon MR3 3.8.30.

METHODS

This study employed an analytical observational design with a *cross-sectional* approach, aiming to compare *tibialis anterior muscle* activity in female fencers with and without a history of injury. The study was conducted at the Tunas Pembangunan University Sports Hall in Surakarta, which is equipped with a Noraxon MR3 3.8.30 *surface electromyography* (sEMG) system as the instrument for measuring muscle activity. Data collection took place from March to April 2025 using standardised procedures. Each study subject was asked to perform a *lunge* movement as instructed by the researcher, after which the activity of the *tibialis anterior muscle* was recorded using sEMG for further analysis.

The population in this study consisted of female fencers who are members of the Central Java Regional Training Centre (Pelatda). There were 12 research subjects, divided into two groups: 6 athletes with a history of lower limb injury and 6 athletes without such a history. Inclusion criteria included female fencers aged 13–24 years, with more than two years' training experience, a history of lower limb injury within



the past year from which they had fully recovered, and a willingness to participate by signing an *informed consent form*. Exclusion criteria included subjects who were experiencing pain or injury at the time of the study and those who did not complete the entire study protocol.

Subjects were selected using a quota sampling technique, with the sample size determined based on injury history categories. Subjects who met the criteria were then grouped according to their injury history status, as determined through interviews. Subsequently, all subjects underwent measurement of *tibialis anterior muscle* activity using *surface electromyography* (sEMG) whilst performing the *lunge* phase in accordance with the established procedure.

Data collection for this study was carried out directly by measuring the activity of the *tibialis anterior muscle* in female fencers using *surface electromyography* (sEMG). The data obtained consisted of muscle activity values recorded during the *lunge* phase performed by each study participant. The entire data collection process was carried out systematically and in a standardised manner to ensure the consistency of the measurement results.

Muscle activity was measured using the Noraxon MR3 3.8.30 *surface electromyography* (sEMG) device, following the electrode placement guidelines set out in the '*Surface Electromyography for the Non-Invasive Assessment of Muscles*' (SENIAM) standard. Prior to recording, subjects were asked to warm up to reduce the risk of injury and improve muscle readiness. The subject then stood upright in a relaxed position. Next, the researcher attached electrodes to the *tibialis anterior muscle* in accordance with the specified anatomical locations.

Following the fitting of the electrodes, the subjects were asked to assume a ready position with their feet positioned in accordance with the designated markers. The subjects then performed

a forward *lunge* at maximum speed towards the designated target. Prior to the main data recording, the subjects were given the opportunity to carry out several trial runs to familiarise themselves with the procedure. Subsequently, each subject performed three *lunges*, and the recorded muscle activity was used as research data.

The data obtained from measurements of *tibialis anterior muscle* activity using *surface electromyography* (sEMG) were first processed through the stages of editing, coding and tabulation. The data were then analysed using statistical software to determine differences in muscle activity between groups of female fencers with and without a history of injury. Prior to hypothesis testing, the data were tested for normality using the Shapiro-Wilk test, as the sample size was less than 30. If the p-value was greater than 0.05, the data were deemed to be normally distributed; if it was less than 0.05, the data were deemed not to be normally distributed.

Next, a bivariate test was conducted to compare the mean *tibialis anterior muscle* activity between the two groups. If the data were normally distributed, a parametric test—specifically an independent t-test—was used; whereas if the data were not normally distributed, the non-parametric Mann-Whitney U test was used. Decision-making was based on the significance value at a 95 per cent confidence level ($\alpha = 0.05$). If the p-value is < 0.05 , the null hypothesis is rejected; it can therefore be concluded that there is a difference in *tibialis anterior muscle* activity in the lower limb's during the *lunge* phase between female fencers with and without a history of injury.

This study has obtained ethical approval from the Health Research Ethics Committee of Muhammadiyah University of Surakarta, No. 1013/KEPK-FIK/III/2025. All participants provided written informed consent prior to the study.



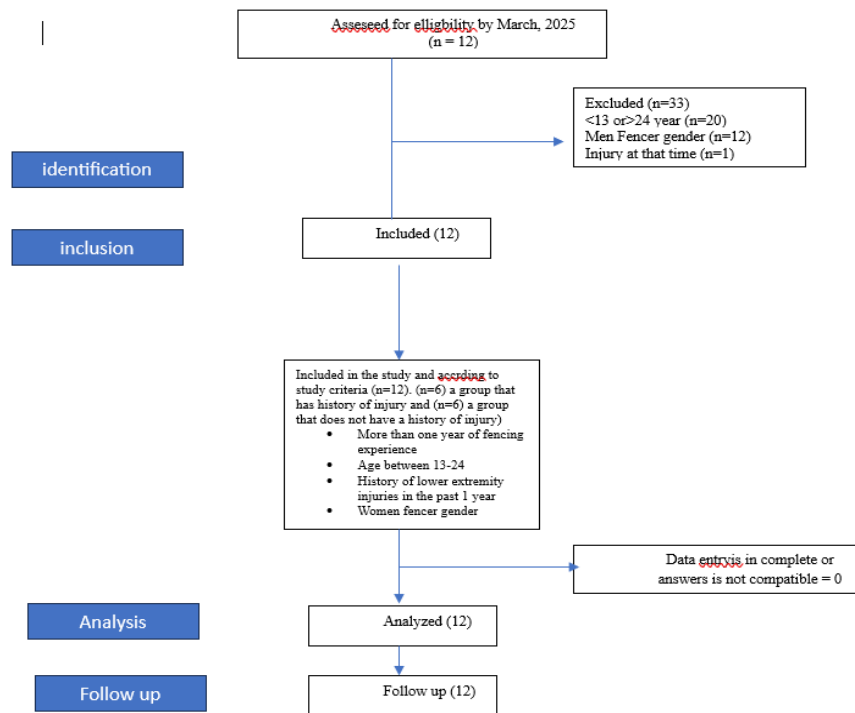


Figure 1. Respondent flowchart

RESULTS

Table 1. Characteristics of respondents in the Study of Differences in Anterior Tibialis Muscle Activity in the Lower Limb during the Lunge Phase in Female Fencers with and without a History of Injury

Characteristics Sample	Injury Group		Non-Injury Group	
	n	%	n	%
Age (years)				
>13				
Gender				
Female	6	100	6	100
BMI				
Normal	3	50	3	50
Underweight	3	50	3	50
Overweight	0	0	0	0
Duration of Training				
>1 year	6	100	6	100

Based on the table 1 of sample characteristics, it was found that the total number of subjects in this study was 12 female fencers, divided into two groups: a group with a history of injury and a group without a history of injury, each comprising 6 subjects (100 per cent). The age distribution showed that all subjects in both groups were in the >13 years age category. Based on body mass index (BMI), in the injury group there were 3 subjects (50 per cent) in the normal category and 3 subjects (50 per cent) in the underweight category. The same pattern was also found in the group without a history of injury, with 3 subjects (50 per cent) in each of the normal and underweight categories. The proportion of athletes with an *underweight* status (50%) is closely linked to the high intensity of training and the demands for agility in the sport of fencing. This condition may affect the load-absorption capacity of the lower limbs, making the dynamic stability of the *tibialis anterior* muscle during the



lunge phase particularly crucial. Furthermore, based on training duration, all subjects in both groups had more than one year's training experience (100 per cent).

Table 2. Tests of Normality and Homogeneity

	Injured Group	Non-injured Group
Muscle	<i>m. Tibialis anterior</i>	<i>m. Tibialis anterior</i>
p-value	0.142	0.143
p-value	0,000	0,000

Based on the Shapiro-Wilk test, all data on muscle activity of the *tibialis anterior*, in the groups of female athletes with and without a history of injury, showed significance values above 0.05. Meanwhile, the homogeneity test for the *tibialis anterior* muscle showed a significance value of 0.000 ($p < 0.05$); consequently, the data for this muscle did not meet the assumption of homogeneity, so the Mann-Whitney U test was used.

Table 3. Hypothesis Testing

	Injured Group	Non-Injury Group
Mean Peak Value	141.91 ±	251.29 ±
M. Tibialis anteorior	30.21	88.50
Difference	-109.38 ±	-109.38±
M. Tibialis anteorior	38.18	38.18
p-value		0.028

Based on the results of the analysis using the Mann–Whitney test, the mean value for tibialis anterior muscle activity in the injury group was 141.91 ± 30.21 , whilst in the non-injury group it was 251.29 ± 88.50 . The results of the statistical test showed a p-value of 0.028 ($p < 0.05$); it can therefore be concluded that there is a significant difference in tibialis anterior muscle activity between female fencers with a history of

injury and those without a history of injury during the lunge phase.

DISCUSSION



Figure 1. Tibialis anterior muscle activity in female fencers with and without a history of injury

Differences: According to the research findings, muscle activity in the tibialis anterior muscle among female fencers with a history of injury was lower than that of athletes without such a history during the lunge phase. This difference indicates a change in muscle activation patterns occurring in response to previous injury. This reduction in tibialis anterior muscle activity may affect the ability to stabilise the ankle, particularly during the initial contact phase of the lunge movement, thereby potentially disrupting balance and movement control.

ANTERIOR TIBIALIS MUSCLE ACTIVITY

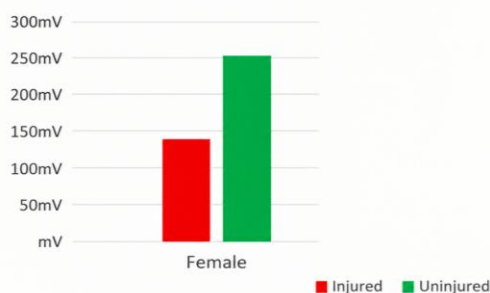


Figure 2. Differences in Tibialis Anterior Muscle Activity in Female Fencers with and without a History of Injury

The reduction in tibialis anterior muscle activation in the group with a history of injury can be explained by the mechanism of arthrogenic muscle inhibition (AMI), a condition in which the neuromuscular system is inhibited as a result of injury to joint tissue. Ferrández-Laliena et al., (2025) state that disruption to joint structures can cause a reduction in the activation of surrounding muscles as a protective response to reduce mechanical load. This condition prevents the muscles from contracting optimally, thereby leading to a reduction in functional performance (Palermi et al., 2023) .

Furthermore, Liu et al., (2025) explain that female athletes tend to reduce distal muscle activation, including the tibialis anterior, as a strategy to minimise stress on vulnerable joints. This strategy is protective in the short term as it helps to reduce the risk of pain and re-injury; however, in the long term, it can lead to a decline in muscle strength and impaired dynamic

stability. Reduced activity of the tibialis anterior muscle is also associated with impaired neuromuscular control, which plays a role in maintaining balance during dynamic movements such as lunges (Steiner et al., 2023) .

Leung et al., (2024) add that the sensorimotor system in women tends to be more sensitive to changes in joint conditions, resulting in a reduced muscle activation response as an adaptation to instability. This is related to proprioceptive ability, which influences postural control, particularly during activities requiring precise movement. Consequently, changes in the activation pattern of the tibialis anterior muscle in athletes with a history of injury are caused not only by structural damage but also by the nervous system's adaptation to these conditions (Drakoulaki et al., 2021) .

The implications of these findings suggest that the reduction in tibialis anterior muscle activity warrants attention in rehabilitation programmes for female fencers. Zhao et al., (2024) suggest that exercises emphasising increased activation of distal stabiliser muscles, such as the tibialis anterior, as well as proprioceptive exercises, may help to restore optimal neuromuscular function. Furthermore, a structured exercise programme incorporating a neuromuscular control approach and balance training is also required to improve ankle stability and reduce the risk of recurrent injury during explosive movements such as lunges (Ford et al., 2025)

Physiotherapy Implications

The finding of a deficit in tibialis anterior muscle activation following injury has important implications for the three main pillars of physiotherapy:

1. Clinical Practice: Sports physiotherapists are advised not only to focus on strengthening proximal muscles (quadriceps and hamstrings), but must also integrate distal stabiliser exercises, such as those for the tibialis anterior muscle, and utilise electromyographic biofeedback training to address neuromuscular barriers (arthrogenic muscle inhibition) before athletes return to sport.

2. Physiotherapy Education: These findings enrich the empirical evidence in the field of sports physiotherapy and applied biomechanics, particularly regarding the understanding of gender-specific sensorimotor adaptations in the lower limb kinetic chain of combat and martial arts athletes.
3. Development of Physiotherapy Services: Portable sEMG devices could be developed as tools for routine, periodic screening (pre-participation screening) at athlete training centres (such as regional training centres) to detect silent neuromuscular deficits before they develop into recurrent injuries.

Limitations of The Study

This study has several limitations that need to be taken into account. The sample size was relatively small ($n = 12$) as the population of female fencers at the Pelatda level who met the inclusion criteria was very limited in the study area. Therefore, the results of this study should be interpreted with caution and cannot yet be widely generalised to the entire population of athletes across all sports. Furthermore, the cross-sectional design does not allow for the drawing of longitudinal causal conclusions. Further research with a larger sample size, utilising a prospective cohort design, and analysing the co-contraction of the antagonist muscle (m. gastrocnemius) is strongly recommended.

CONCLUSION

This study concluded that there was a significant difference in tibialis anterior muscle activity between female fencers with and without a history of injury during the lunge phase, with the group with a history of injury exhibiting lower levels of muscle activation. This reduction in activation reflects adaptive changes in neuromuscular control that may compromise ankle stability during dynamic manoeuvres.

Given the relatively small sample size, these findings should be interpreted with caution as preliminary evidence. In practical terms, physiotherapists and fencing coaches are recommended to implement rehabilitation and injury prevention programmes that focus on the

activation of distal stabiliser muscles and structured neuromuscular control exercises in order to optimise movement performance and minimise the risk of recurrent injury in female fencers.

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