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Abstract

Background: Recent epidemiological analyses in fencing have shown that injuries and pain linked specifically to fencing training/competition were evident in 92.8% of fencers. Specifically the prevalence of Achilles tendon pathology has increased substantially in recent years, and males have been identified as being at greater risk of Achilles tendon injury compared to their female counterparts. This study aimed to examine gender differences in Achilles tendon loading during the fencing lunge. Material/Methods: Achilles tendon load was obtained from eight male and eight female club level epee fencers using a 3D motion capture system and force platform information as they completed simulated lunges. Independent t-tests were performed on the data to determine whether differences existed. Results: The results show that males were associated with significantly greater Achilles tendon loading rates in comparison to females. Conclusions: This suggests that male fencers may be at greater risk from Achilles tendon pathology as a function of fencing training/competition.

Keywords

fencing, injury, Achilles tendon

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Gender differences in the Achilles tendon load during the fencing lunge

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Authors' Contribution:
A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

Key words: *fencing, injury, Achilles tendon.*

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Introduction

Fencing represents an Olympic discipline in which athletes aim to strike an opponent with their sword. Recent epidemiological analyses in fencing have shown that injuries and pain linked specifically to fencing training/competition were evident in 92.8% of fencers [1]. Furthermore, it has also been demonstrated that the majority of these injuries are experienced by the lower extremities in fencers [1]. The continuous dynamic motions that are associated with fencing are considered to expose the musculoskeletal structures to high transient forces [2, 3]. In particular, the lunge movement, which forms the basis of the majority of offensive motions in fencing, repeatedly exposes participants to potentially detrimental impact forces [2].

The Achilles tendon represents a confluence of the gastrocnemius and soleus muscles. The tendon itself is inserted on the posterior surface of the calcaneus distal to the tuberosity. In recent years the prevalence of Achilles tendon pathology has increased substantially as a result of greater participation in sports activities [4]. Research has shown a genetic predisposition to of Achilles tendon pathology [5, 6]; however, between the sexes, males have been identified as being at greater risk of Achilles tendon injury by a factor of 2:1 to 12:1 compared to their female counterparts [7, 8].

Despite the potential gender differences in injury aetiology of the Achilles tendon, there is a paucity of research investigating any potential differences in loading of the tendon during epee fencing. The aim the current investigation was to determine whether gender differences in Achilles loading exist during the impact phase of the fencing lunge.

Material and methods

Participants. Eight male participants and eight female participants volunteered to take part in this investigation. All were injury free at the time of data collection and provided written informed consent in accordance with the declaration of Helsinki. Participants were active competitive fencers who engaged in training a minimum of 3 training sessions per week. The mean characteristics of the participants were males; age 29.18 ± 4.30 years, height 1.79 ± 0.05 m and mass 75.33 ± 6.28 kg and females; age 23.04 ± 5.57 years, height 1.67 ± 0.06 m and mass 63.57 ± 3.66 kg. The procedure was approved by the University of Central Lancashire ethics committee.

Procedure. Participants were required to complete 10 lunges hitting a dummy with their weapon whilst returning to a starting point [pre-determined by each participant prior to the commencement of data capture) following each trial to control lunge distance. In addition to striking the dummy with their weapon participants also made contact with a force platform (Kistler, Kistler Instruments Ltd., Alton, Hampshire) embedded into the floor (Altrosports 6mm, Altro Ltd.) of a biomechanics laboratory with their right (lead) foot. The force platform sampled at 1000 Hz.

Kinematic information was captured at 250 Hz via an eight camera motion analysis system (QualisysTM Medical AB, Goteburg, Sweden). Calibration of the QualysisTM systems was performed before each data collection session. To ensure high quality kinematic data was obtained, only calibrations which produced average residuals of less than 0.85 mm for each camera for a 750.5 mm wand length and points above 4000 in all cameras were accepted prior to data collection in accordance with Sinclair et al. [9].

The anatomical marker set used in the current investigation was based on the calibrated anatomical systems technique (CAST) technique [10]. Retro-reflective markers were attached to the 1st and 5th metatarsal heads, medial and lateral malleoli, calcaneus and medial and lateral epicondyle of the femur. This allowed the right (lead) foot and shank to be defined. The foot was tracked using the 1st and 5th metatarsal and calcaneus markers, whilst the shank was tracked with a rigidly attached tracking cluster. The tracking cluster comprised four 19 mm spherical reflective markers mounted to a thin sheath of lightweight carbon fibre, in accordance with the Cappozzo et al., [11] recommendations. Static calibration trials (not normalized to standing posture) were conducted with the participant in the anatomical position allowing the positions of the anatomical markers to be referenced in relation to the tracking clusters, following which they were removed. Participants wore the same fencing footwear throughout (Hi-Tec blade), in sizes 5-10 UK.

Data Processing. Trials were digitized using Qualisys Track Manager to identify anatomical and tracking markers then exported as C3-D files in to Visual 3-D (C-Motion, Germantown, MD, USA). Marker trajectories and kinetic information were filtered using a low-pass Butterworth 4th order zero-lag filter at cut off frequencies of 15 and 50 Hz. Ankle joint kinetics were computed using Newton-Euler inverse-dynamics. Net external ankle joint moments were then calculated. Trials were time normalized from the instance of footstrike to the point of maximum knee flexion.

An algorithmic technique was used to quantify Achilles tendon load. This algorithm has been used previously to determine differences in Achilles tendon kinetics when running with different footwear [12, 13]. Achilles tendon force (ATF) was determined by dividing the plantarflexion moment (PFM) by the estimated Achilles tendon moment arm (atMA). The moment arm was quantified as a function of the ankle sagittal plane angle (SAK) using the procedure described by Self and Paine [14].

$$ATF = PFM / atMA$$

$$MA = -0.5910 + 0.08297\ SAK - 0.0002606\ SAK^2$$

ATF was normalized to bodyweight (B.W) and ATF loading rate (B.W.s-1) was also calculated as a function of the change in tendon force from initial contact to peak force divided by the time to peak force. Instantaneous Achilles tendon loading rate (B.W.s-1) was taken as the maximum increase in tendon force between frequency intervals. In addition the Achilles tendon moment arm length and GRF's at the instance of peak plantarflexion moment were also obtained.

Statistical Analyses. Descriptive statistics (means ± standard deviations) were calculated for each gender. Gender differences in kinetic and 3-D kinematic parameters were examined using independent samples t-tests with significance accepted at the $p \leq 0.05$ level. Effect sizes for all significant observations were calculated using Cohen's D. The data was screened for normality using Shapiro Wilk tests, which conformed that the normality assumption had not been violated. All statistical procedures were conducted using SPSS v21.0.

Results

Table 1 and Figure 1 present the Achilles tendon kinetics obtained as a function of gender. The results indicate gender significantly influenced Achilles tendon kinetics.

Achilles tendon load

Table 1. Achilles tendon force measurements as a function of gender

Achilles tendon force measurements	Male	SD	Female	SD
Peak dorsiflexion (°)	19.84	5.05	25.08	4.84
Peak plantarflexion moment (N.m.kg)	1.68	0.78	1.17	0.89
Peak tendon force (B.W)	2.36	0.89	1.85	0.32
Time to peak force (s)	0.16	0.06	0.14	0.04
Average tendon loading rate ($B.W.s^{-1}$)	14.75	8.62	12.05	9.87
Instantaneous tendon loading rate ($B.W.s^{-1}$)	22.47	12.08	18.55	10.56

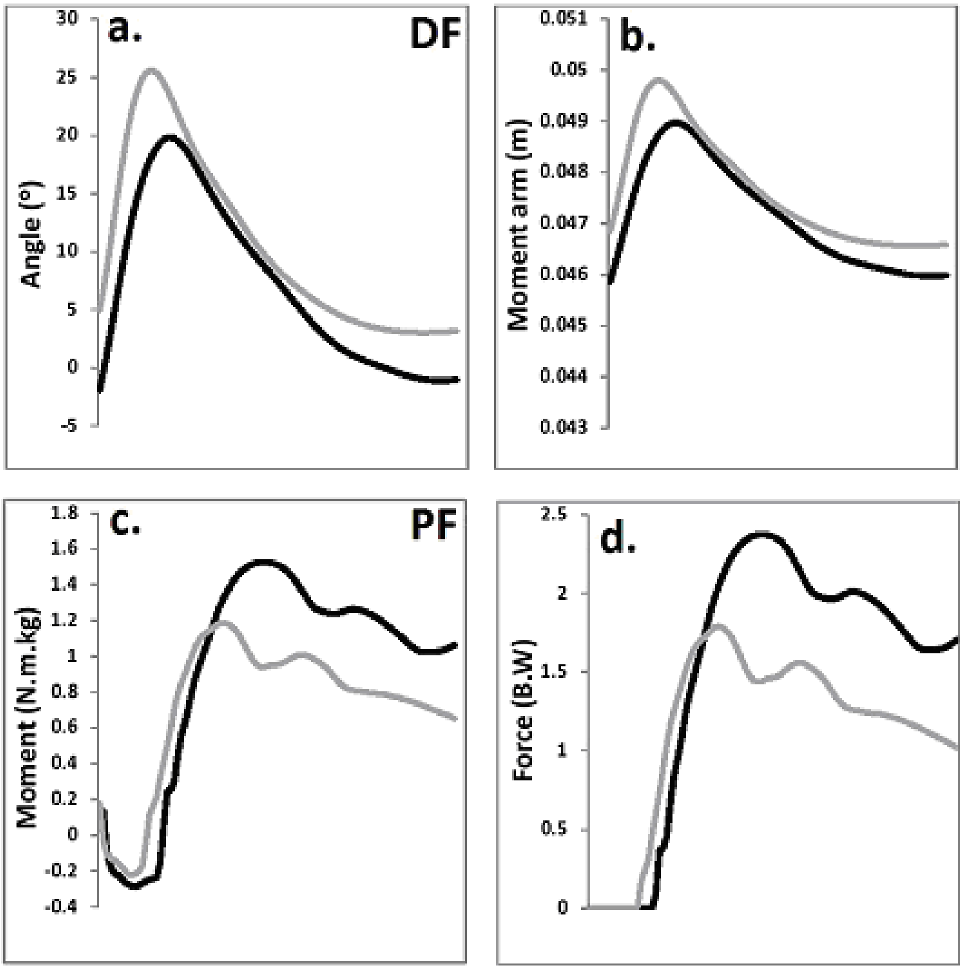

Fig. 1. Ankle kinetics and kinematics as a function of gender, black = male, Grey = female (a= ankle angle, b = Achilles tendon moment arm, c = ankle moment, d = Achilles tendon load) (DF = dorsiflexion, PF = plantarflexion).

Ground reaction forces and moment arm length

No significant ($p>0.05$) differences in medio-lateral (male = 0.07 ± 0.05 B.W, female = 0.08 ± 0.06 B.W), anterior-posterior (male = 0.54 ± 0.13 B.W, female = 0.51 ± 0.16 B.W) or vertical (male = 1.85 ± 0.66 B.W, female = 1.80 ± 0.67 B.W) were found. Males (0.047 ± 0.01 m) were however shown to be associated with a significantly $t(7) = 3.55$, $p<0.05$, $D = 2.68$ shorter tendon moment arm at peak moment compared to females (0.048 ± 0.01 m).

Females were shown to be associated with a significantly $t(7) = 2.92$, $p<0.05$, $D = 2.20$ larger dorsiflexion angle. Males were however associated with a significantly larger $t(7) = 2.89$, $p<0.05$, $D = 2.18$ peak plantarflexion moment compared to females. The results from the tendon kinetic analysis indicate that males exhibited a significantly $t(7) = 2.99$, $p<0.05$, $D = 2.26$ higher peak tendon force than females. Furthermore, it was shown that males were associated with significantly greater average $t(7) = 2.65$, $p<0.05$, $D = 2.00$ and instantaneous $t(7) = 2.69$, $p<0.05$, $D = 2.03$ Achilles tendon loading rates in comparison to females.

Discussion

The aim of the current investigation was to determine whether gender differences in Achilles loading exist during the fencing lunge. This represents the first to examine magnitude of Achilles tendon kinetics in fencing.

The primary observation from this study is that males were associated with significant increases in Achilles tendon force and rates of loading. This finding may be relevant clinically for the pathogenesis of Achilles tendinopathy and provide insight into the mechanism by which males athletes suffer from increased incidence of Achilles tendon pathology [12]. The aetiology of Achilles tendinopathy is considered to be associated with habitual and excessive mechanical loading of the tendon. Tendon loads that fall outside the tolerable levels of loading initiates collagen and extracellular matrix synthesis and facilitate degradation of the tendon itself [15, 16, 17, 18, 19, 20]. The findings from this study suggest that male fencers performing the lunge movement will experience additional loads at the Achilles tendon. Therefore, although additional work using a longitudinal design is required, it is likely that male fencers are at increased risk from Achilles tendon pathology.

It is hypothesized that the increases in Achilles tendon load in male fencers relates to the increased plantarflexion angle throughout the lunge movement. Increases in the plantarflexion angle are associated with a shortening of the moment arm of the Achilles tendon, which ultimately leads to an increase in the load experienced by the Achilles tendon [13, 14]. With the observation that GRF's did not differ between males and females, this provides further evidence as to why increases in Achilles tendon load were observed in male fencers.

There are some limitations to the current study design/ protocol that should be acknowledged to contextualise the findings. The average body mass of the male fencers was higher than females and as such an increase in the absolute non-normalized force is higher in the male group. With this in mind recent evidence has shown that body mass can accounts for only 6 - 30% of the variance in Achilles tendon breadth [21]; therefore, normalising Achilles tendon kinetic parameters to bodyweight may require further consideration in future studies.

Conclusions

In conclusion, this study adds to the current knowledge by providing a comprehensive evaluation of Achilles tendon kinetics measured for both males and females during the fencing lunge. The significant increase in the Achilles tendon loading rate in male fencers suggests that they are more susceptible to the development of chronic injuries in comparison to females. Future research should investigate further the long term effects of regular fencing training and competition on Achilles tendinopathy. Prospective epidemiological analyses using randomised controlled trails should also be a focus for future investigations into the aetiology of Achilles tendon pathology in fencers.

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References

1. Harmer PA. Getting to the point: injury patterns and medical care in competitive fencing. Curr Sp Med Reports. 2008;7:303-307.
2. Sinclair J, Bottoms L, Taylor K, Greenhalgh A. Tibial shock measured during the fencing lunge, the influence of footwear. Sp Biomech. 2010;9:65-71.
3. Greenhalgh A, Bottoms L, Sinclair J. Influence of surface conditions on impact shock experienced during a fencing lunge. J App Biomech. 2013;29:463-467.
4. Selvanetti ACM, Puddu G. Overuse tendon injuries: basic science and classification. Op Tech Sp Med. 1997;5:110-17.
5. Kraemer R, Wuerfel W, Lorenzen J, Busche M, Vogt PM, Knobloch K. Analysis of hereditary and medical risk factors in Achilles tendinopathy and Achilles tendon ruptures: a matched pair analysis. Arch Orthop Traum Su. 2012;132:847-853.
6. Ribbans WJ, Collins M. Pathology of the tendo Achillis: Do our genes contribute? The Bone & Joint Journal. 2013;95:305-313.
7. Hess GW. Achilles tendon rupture: a review of etiology, population, anatomy, risk factors, and injury prevention. Foot Ankle Spe. 2010;3:29-32.

8. Vosseller JT, Ellis SJ, Levine DS, et al. Achilles Tendon Rupture in Women. Foot Ankle Int. 2013;34:49-53.
9. Sinclair J, Greenhalgh A, Edmundson CJ, Brooks D, Hobbs SJ. The efficacy of barefoot and shod running and shoes designed to mimic barefoot running. Footwear Sci. 2013;5:45-53.
10. Cappozzo A, Catani F, Leardini A, Benedeti MG, Della CU. Position and orientation in space of bones during movement: Anatomical frame definition and determination. Clin Biomech. 1995;10:171-178.
11. Cappozzo A, Cappello A, Croce U, Pensalfini F. Surface-marker cluster design criteria for 3-D bone movement reconstruction. IEEE Trans Biomed Eng. 1997;44:1165-1174.
12. Kulmala JP, Avela J, Pasanen K, Parkkari J. Forefoot strikers exhibit lower running-induced knee loading than rearfoot strikers. Med Sci Sports Exerc, 2013; 45: 2306-2313.
13. Self BP, Paine D. Ankle biomechanics during four landing techniques. Med Sci Sports Exerc, 2011; 33: 1338–1344.
14. Selvanetti A, Cipolla M, Puddu G. Overuse tendon injuries: basic science and classification. Oper Techn Sport Med, 1997; 5: 110–117.
15. Sinclair J. Effects of barefoot and barefoot inspired footwear on knee and ankle loading during running. Clin. Biomech, 2014;29:395-399.
16. Magnusson SP, Langberg H, Kjaer M. The pathogenesis of tendinopathy: balancing the response to loading. Nat Rev Rheuma, 2010;6:262-268.
17. Kirkendall DT, Garrett WE. Function and biomechanics of tendons. Scand J Med Sci Sports. 1997;7:62-66.
18. Miller BF, Hansen M, Olesen JL, et al. Tendon collagen synthesis at rest and after exercise in women. J Appl Physiol. 2007;102:541-546.
19. Moore JS. Function, structure, and responses of components of the muscle-tendon unit. Occup Med. 1992;7:713-740.
20. Westh E, Kongsgaard M, Bojsen-Moller J, et al. Effect of habitual exercise on the structural and mechanical properties of the human tendon, in vivo, in men and women. Scand J Med Sci Sports. 2008;18:23-30.
21. Wearing SC, Grigg NL, Hooper SL, Smeathers JE. Conditioning of the Achilles tendon via ankle exercise improves correlations between sonographic measures of tendon thickness and body anthropometry. J App Physiol. 2011;110:1384-1389.