SEX-BASED DIFFERENCES IN BIOMECHANICAL RISK FACTORS FOR TIBIAL STRESS FRACTURES AMONG ROYAL NAVAL RECRUITS

Bunclark, H.P.J.[1], Ellison, M.[1], Fallowfield, J.L.[2], & Dixon, S.J.[1]
[1]University of Exeter, Public Health and Sport Sciences, St. Luke's Campus, Exeter, UK
[2]Institute of Naval Medicine, Gosport, UK
Email: hb792@exeter.ac.uk

Summary

Tibial stress fractures are problematic in military populations, where biomechanical risk factors may differ by sex. This study examined biomechanical variables previously linked to tibial stress fractures in male Royal Marines and female distance runners, within a cohort of male and female Royal Naval trainees. Female trainees exhibited increased left-sided vertical average loading rates, lower peak knee internal rotation, and greater peak hip adduction bilaterally; factors associated with elevated tibial stress fracture risk. This study's findings support the requirement for targeted interventions to address sex-specific injury risk factors in military training.

Introduction

During military training, trainees are at risk of lower limb overuse injuries, including tibial stress fractures. These injuries affect the trainees themselves and present additional financial costs for military organisations. Sex-related biomechanical differences have been associated with potential altered lower limb load distribution and stress fracture risk [1]. Specifically, greater vertical ground reaction force magnitude and loading rates, peak rearfoot eversion, hip adduction, and lower tibial internal rotation have been associated with greater tibial stress fracture risk [2,3]. However, there is limited research comparing these variables in a male and female military cohort. This study explored whether these variables differ between male and female Royal Naval trainees.

Methods

Royal Naval trainees (Table 1) were randomly selected during week 2 of initial Naval training for kinematic and synchronised force plate data capture. Participants ran shod at a self-selected speed (± 5%). Biomechanical variables were extracted during the stance phase, including: active peak, impact peak, peak loading rate, and average loading rate (3-12% of stance), and peak rearfoot eversion, knee internal rotation, hip adduction. Kinetics were adjusted for Body Weight (BWs) and kinematics for standing position. Due to the potential for asymmetry between variables [4], left and right variables were analysed separately, with means compared between sexes using independent t-tests ($\alpha = 0.05$).

Table 1: Participant Demographics with Mean Values

Sex	N	Age	Height (m)	Weight (kg)	Gait Speed ($m.s^{-1}$)
Male	176	20.6(4.12)	1.78(0.07)	75.39(11.15)	2.78(0.42)
Female	109	21.0(4.3)	1.65(0.07)	65.54(9.50)	2.72(0.46)

Results and Discussion

Males exhibited significantly greater left active peak force compared to females (Male = 2.27 ± 0.23 BW, Female = 2.19 ± 0.22 BW; P = 0.009, d = 0.319), but females experienced greater left-sided average loading rates (Male = 46.14 ± 12.42 BW/s, Female = 49.21 ± 11.82 BW/s; P = 0.020, d = 0.251). Kinematic analysis (Table 2) revealed that females had significantly lower tibial internal rotation and greater hip adduction during stance bilaterally. These findings may suggest that males have a greater ability to dissipate ground reaction forces at initial impact more effectively while running; this may be related to hip and knee mechanics during stance. The cumulative effect of increased capacity for impact load mitigation may reduce the risk of lower limb bone stress injuries. Previous prospective research has identified lower tibial internal rotation as being associated with increased tibial stress fracture risk in a sample of male Royal Marine trainees. Furthermore, retrospective research found that greater peak hip adduction in females during stance was associated with increased tibial stress fracture risk in a population of female runners. Nonetheless, prospective investigations are warranted to elucidate the relationship between hip mechanics and the incidence of tibial stress fractures [1]. Thus, female Royal Navy trainees may be at greater risk for tibial stress fractures due to a reduced ability to attenuate ground reaction forces through knee and hip mechanics during the stance phase of running.

Table 2: Kinematic Variable Comparison

Variable	Foot Contact	Male Value (±) (Degrees)	Female Value (±) (Degrees)	P	Effect Size
Peak Eversion	Left	-10.01 (4.69)	-10.53 (4.45)	0.187	0.114
	Right	-9.78 (4.35)	-10.27 (4.38)	0.185	0.112
Peak Tibial IR	Left	15.99 (5.65)	12.85 (5.90)	<0.001*	0.545
	Right	13.61 (5.87)	11.36 (5.27)	<0.001*	0.398
Peak Hip Adduction	Left	8.90 (4.44)	10.48 (3.56)	<0.001*	0.383
	Right	9.79 (4.37)	10.93 (4.64)	0.021*	0.254

Key: ± indicates standard deviation, IR denotes internal rotation.

Conclusions

Sex-related kinetic and kinematics differences exist in Royal Naval trainees. Prospective research monitoring injuries is required to understand if these sex-specific differences are associated with greater tibial stress fracture risk in relation to tibial stress fracture injury risk.

References

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