COMPARISON OF STATIC AND DYNAMIC BIOMECHANICAL MEASURES IN MILITARY RECRUITS WITH AND WITHOUT A HISTORY OF THIRD METATARSAL STRESS FRACTURE

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INTRODUCTION

For Royal Marines in training, the third metatarsal is the most common site for stress fracture occurrence [1]. Previous evidence regarding factors contributing to stress fracture development is conflicting [2,3], possibly due to the lack of differentiation between stress fracture sites. It has recently been demonstrated that the third metatarsal is less able to withstand horizontal than vertical loads [4], suggesting horizontal loading may be important in development of this injury. The present study compares static anatomical and dynamic biomechanical variables for Royal Marine recruits with and without a history of third metatarsal stress fracture.

METHODS

Ten Royal Marine recruits with a history of third metatarsal stress fracture were matched with control subjects with no previous stress fracture. Selected static variables, including subtalar neutral position, ankle dorsi-flexion and forefoot varus, were measured to describe the anatomy of the lower limb. Each subject also performed running trials in the laboratory wearing military boots. Synchronized ground reaction force and kinematic were collected for 10 trials for both sides of the body. Force plate data were collected at 960 Hz using an AMTI force plate (AMTI, Massachusetts, USA), and three-dimensional kinematic data at 120 Hz using a Peak realtime system (Peak Technologies, USA). For each running trial, peak ankle dorsi-flexion, rearfoot eversion and knee flexion were identified. Horizontal ground reaction force (GRF) was characterized using the peak resultant horizontal force magnitude (contributed to by the anterior/posterior and medial/lateral force components) and the angle of application of this force during braking and propulsion. Application angle was defined as the angle of the resultant horizontal force relative to the sagittal plane, with a negative angle indicating a medially applied force. A matched-pairs Wilcoxon test was used to detect significant differences between the study groups, using data for the stress fracture side for the injury subjects and the same side for each matched control ($p<0.05$).

RESULTS AND DISCUSSION

No significant differences in static anatomical variables were identified between study groups ($p>0.05$). Both static and dynamic ankle dorsi-flexion were lower for the stress fracture group (Table 1), but differences were not significant. During running, rearfoot eversion was found to occur significantly earlier for the stress fracture group than for the matched controls ($p<0.05$, Table 1), suggesting an increased time spent loading the forefoot. No significant differences were identified in peak magnitude of horizontal braking or propulsive force, but the peak horizontal braking force was directed significantly more medially for the stress fracture group ($p<0.05$, Table 1). This suggests a difference in horizontal loading of the foot at this time. Since the third metatarsal is more vulnerable under horizontal than vertical loading [4], this may have implications regarding the mechanism of this injury.

CONCLUSIONS

The measurement of dynamic biomechanical data has highlighted variables associated with third metatarsal stress fracture, indicating the importance of dynamic measurements when investigating risk factors for this injury. The earlier peak eversion, together with the difference in horizontal loading direction during the braking phase, suggest a difference in loading of foot structures that may contribute to this stress fracture development and thus warrants more detailed investigation.

REFERENCES

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Table 1: Static variables, dynamic kinematics and GRF data for stress fracture and control subjects (mean SD, *p<0.05).

	Static variables			Dynamic kinematic variables			Dynamic GRF variables	
	Subtalar neutral (°)	**Forefoot varus (°)**	**Ankle dorsi-flexion (°)**	**Peak eversion (°)**	**Peak eversion time (%)**	**Peak ankle dorsi-flexion (°)**	**Angle of braking force (°)**	**Angle of propulsive force (°)**
Stress fracture	4.9 ± 2.7	5.5 ± 6.1	6.4 ± 2.9	7.7 ± 4.1	39.7* ± 6.5	14.8 ± 3.2	-13.1* ± 6.3	-4.4 ± 7.0
Controls	4.2 ± 4.1	3.1 ± 7.1	7.6 ± 3.0	7.7 ± 2.5	45.6 ± 7.1	16.4 ± 3.2	-6.4 ± 6.7	-7.4 ± 8.2