IDENTIFYING RISK FACTORS FOR STRESS FRACTURE IN MILITARY CADETS – A PROSPECTIVE STUDY

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INTRODUCTION

Overuse injuries, such as lower limb stress fractures, are a major concern to active individuals and military populations. The risk of stress fracture development is over 20% in track and field athletes [1] and 31% in male Israeli military recruits [2]. Foot structure is considered a risk factor in the development of overuse injuries [3,4] as this may influence the ground reaction forces attenuated during locomotion.

The primary purpose of this study was to determine the differences in foot structure and ground reaction forces between cadets who go on to sustain a lower limb stress fracture vs. those who remain injury free. We hypothesized that cadets who sustained a lower limb stress fracture would have dissimilar foot structure and larger ground reaction forces compared to uninjured controls.

METHODS

Incoming cadets at the United States Military Academy (USMA) participated in this study after providing IRB approved informed consent. Injury incidence, type and location were recorded for 1063 cadets (887 males / 176 females) over the following year (7/1/2013 through 6/30/2014). Complete injury incidence over this first year is shown in Figure 1.

Twenty individuals who sustained lower limb stress fractures (STFX) (9 male / 11 female) and 589 uninjured controls (CRTL) (523 / 66) had complete data sets and were included in this analyses (demographics shown in Table 1). Three individuals (2 male / 1 female) sustained bilateral lower limb stress fracture and each limb was included separately. Cadets who sustained other injuries were excluded from this analysis.

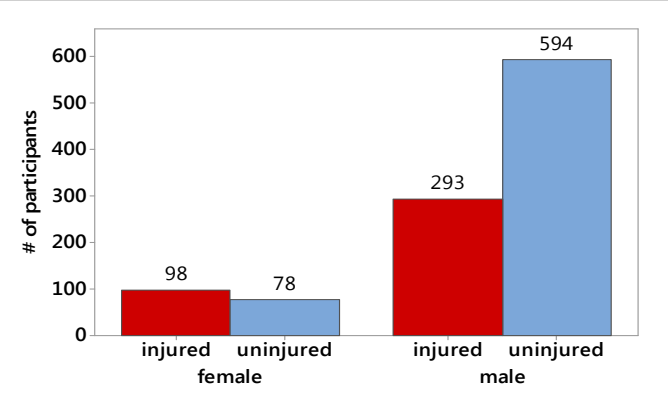

Figure 1: All injury data for 1063 cadets during the first year at USMA – West Point.

Table 1. Participant demographics for STFX and CTRL displayed as mean ± standard deviation

		n	age (y)	ht (m)	mass (kg)
M	STFX	11	18.4±0.5	1.77±0.40	73.0±6.2
	CTRL	523	18.5±0.7	1.78±0.76	78.3±11.5
F	STFX	9	17.7±0.8	1.66±0.65	63.8±9.2
	CTRL	66	18.2±1.2	1.66±0.67	62.6±7.0

Each participant underwent foot structure measurement and gait pressure analysis prior to injury incidence. Arch height index (AHI) was calculated by measuring dorsal arch height and normalizing to truncated foot length. This measure was recorded in both the seated and standing position (AHIsit and AHIstand), and the difference

between seated and standing (AHIdiff) was calculated. Participants walked across a pressure sensor platform (emed; Novel; Munich, Germany) making a direct foot strike with the left or right foot. A 12-segment mask was applied to each trial and maximal force was calculated for each anatomical plantar region. We investigated the following force variables: highest maximal force in any of the 12 anatomical regions (MF_total), the average maximal force over the 5 metatarsal regions (MF_meta), and the average maximal force over the 2 heel regions (MF_heel). Ensemble averages were calculated for 5 strikes of each foot and force magnitudes were normalized by body mass. The injured limbs measurements were compared to the average of both limbs in the uninjured controls.

Non-parametric statistics were chosen after an initial inspection of the data revealed the majority of variables were not normally distributed (Anderson-Darling test; $p<0.05$). Kruskal-Wallis tests were used to test for differences between the STFX cohort and uninjured controls. A p-value <0.05 was used to indicate statistical significance.

RESULTS AND DISCUSSION

Contrary to our hypotheses, no differences in AHIsit, AHIstand or AHIdiff were found between the STFX and uninjured control groups for either sex (Table 2). Men who sustained a lower limb stress fracture did exhibit greater normalized MF_total compared to uninjured controls ($p<0.05$), but this difference was not seen in females. No differences were found in either normalized MF_meta or MF_heel. Post-hoc analysis revealed that STFX men were significantly lighter than uninjured controls ($p=0.026$).

CONCLUSIONS

Normalized MF_total was significantly larger in males who sustained a lower limb stress fracture compared to uninjured, which may load the lower limb in a way predisposing them to injury. Contrary to our hypotheses, we found no differences between groups for normalized maximal forces on the metatarsal or heel area or AHI measures. Females had a marked increase in overall injury rates compared to males, 55.7% vs. 33.0% respectively. Lower limb STFX also accounted for 10.2% of all injuries in females and 4.4% of all injuries in males. Development of lower limb stress fractures is likely multifactorial and further study is needed to understand the mechanisms precipitating an injury and the differing rates between males and females.

REFERENCES

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Table 2. Median and interquantile ranges reported. Kruskal-Wallis test between lower limb stress fracture and control groups by sex. ***** $p < 0.05$

		n	AHIsit	p	AHIstand	p	AHIdiff	p
M	STFX	13	0.34 [0.07]	0.97	0.32 [0.07]	0.98	0.024 [0.010]	0.35
	CTRL	523	0.35 [0.04]		0.33 [0.03]		0.022 [0.099]	
F	STFX	10	0.36 [0.02]	0.62	0.33 [0.02]	0.48	0.023 [0.016]	0.34
	CTRL	66	0.36 [0.04]		0.33 [0.04]		0.027 [0.012]	
			MF_total (N/kg)		MF_meta (N/kg)		MF_heel (N/kg)	
M	STFX	13	9.81 [0.53]	**0.01***	2.97 [0.69]	0.43	3.57 [0.74]	0.13
	CTRL	523	9.49 [0.75]		2.83 [0.48]		3.33 [0.66]	
F	STFX	10	9.88 [1.09]	0.62	3.29 [1.05]	0.79	3.16 [1.33]	0.69
	CTRL	66	9.64 [0.75]		2.94 [0.39]		3.26 [0.54]	