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THE INFLUENCE OF FATIGUING RUNNING ON MUSCULAR AND FOOT LOADING PARAMETERS – INVESTIGATIONS FOR UNDERSTANDING THE AETIOLOGY OF STRESS FRACTURES

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INTRODUCTION

Repetitive sub-maximal stimuli may reduce the individual loading capacity of the bone and lead to structural changes in the regions of maximal stress that may develop into stress reactions (Wolff 2001). These so called stress or fatigue fractures account for a high percentage of running related injuries (Matheson et al. 1987). The localizations of these fractures are concentrated on the tibia, navicular and the metatarsals in runners (Brukner et al. 1996). Stress fractures in the metatarsals predominantly affect the second and third ray (Fredericson et al. 1997). One of the tasks of the extrinsic and intrinsic foot muscles during running activities is to absorb energy in the landing phase in order to minimize (bending) forces to the bones. A gradual loss of muscle force may cause increased loading (Garrett et al. 1987). Therefore, it was the aim of a series of studies to investigate the potentially harmful effects of running under fatigued conditions in order to better understand the pathomechanics of stress fractures.

METHODS

- Surface EMG (Noraxon Myosystem) and foot loading measurements (Novel Pedar) were performed initially during treadmill running near the anaerobic threshold in 30 experienced runners (Tab. 1). Dynamic EMG signals were recorded from 14 lower extremity muscles with bipolar surface electrodes (Weist et al. 2004).
- In a second project, runners were measured during barefoot walking (Novel Emed) before and immediately after participating in the Münster Marathon (Nagel et al. 2007)
- The most recent project investigated barefoot and in-shoe loading characteristics at the beginning, during and at the end of a 25 km run at a constant, moderate speed.

Tab. 1: Subject characteristics (n=30).

	Mean	SD
Age (years)	34.5	8.8
Height (m)	1.78	0.08
Weight (kg)	69.6	8.9
Body mass index (kg/m²)	22.0	2.0
Foot Shape Index (width/length %)	9.1	9.7
Running distance (km/week)	60.8	28.2
Lactate at termination (mmol/l)	6.7	1.7
Running speed (km/h)	14.8	1.3
Running duration (min)	13.6	6.5
Final heart rate (beats per min)	184	13

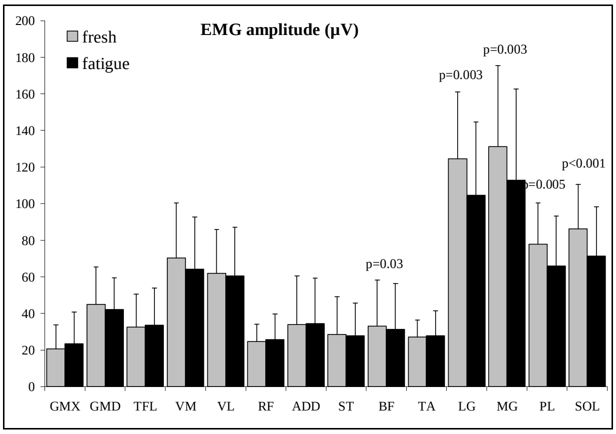

Fig. 1: EMG amplitudes before and after the fatiguing run.

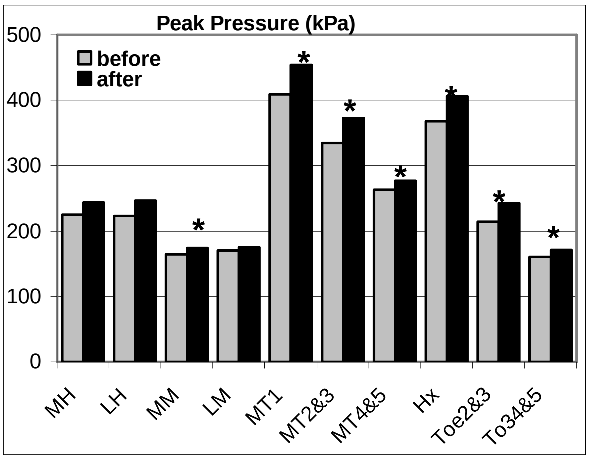

Fig. 2: Peak pressures before and after the fatiguing run.

RESULTS

- The treadmill measurements indicated that there was a decline in EMG amplitudes (Fig. 1) predominantly in the shank muscles. This observation coincided with increase peak pressure values under the metatarsal heads and toes (Fig. 2).
- The pre-/post-race pressure measurements revealed an increased forefoot loading and a decreased toe loading which indicated a gradual loss of push-off forces.
- The measurements at the beginning, during and at the end of the long run support these findings because a similar load shift could be observed.

DISCUSSION

The observed effects of increased forefoot loading under fatigued conditions might help to understand the occurrence of stress fractures. It appears that the muscles controlling the landing phase are fatigued and will not be able to maintain their function in transferring axial forces to the metatarsals and preventing bending/limiting stress (Jacob et al. 1999). Therefore, a preventive measure would be to strengthen the respective muscle groups and/or to support the bony structures at danger with appropriate orthotic insoles.

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