CHANGES IN EMG SIGNALS WHILE RUNNING ON DIFFERENT SURFACES

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The purpose of this study was to quantify changes in EMG signals while running on different surface conditions. Volunteers (n = 47) participated in a study, where surface EMG was recorded from six muscles of the lower extremity while running on three different surfaces (barefoot on grass, barefoot on tartan, shod on tartan). Different surface conditions led to changes in muscle activation within all subjects. Muscle activation patterns were highly individual and different for men and women. Changes of activity patterns depending on running surface were muscle specific and clearly different between gender groups. A deeper understanding of muscular activation while running may yield valuable information for future footwear design and injury sources.

KEY WORDS: EMG, running barefoot, wavelet.

INTRODUCTION: Several studies revealed no systematic changes of ground reaction forces depending on stiffness of midsole (Kersting, 1999; Nigg et al., 1987). As a possible explanation, footwear dependent muscle activation is considered. The effects of changing muscular activation in running are poorly understood. This is viewed as an area for future research because of the potential interaction between boundary conditions in running and muscular activation (Nigg et al., 1995). Therefore the purpose of this study was to investigate muscle activity based on running surface condition in order to: a) quantify surface-related changes in EMG signals and b) investigate inter-individual / gender specific differences in muscular activation.

METHODS:

Data Collection: 20 female (26 ± 5 yrs, 62 ± 5 kg, 170 ± 5 cm) and 27 male (26 ± 5 yrs, 75 ± 8 kg, 180 ± 5 cm) subjects participated in the study. Surface EMG was recorded (sampling frequency 3000 Hz) from m. tibialis anterior, m. peroneus longus, m. gastrocnemius lateralis, m. semitendinosus, m. vastus medialis and m. tensor fasciae latae while running barefoot on grass, barefoot on tartan and with shoes (Straprunner V, Nike) on tartan. The running speed was determined at 3.75 ± 0.25 m/s and controlled by photocells.
Before placing the electrodes with regard to the direction of muscle fibres, the skin was shaved and cleaned with alcohol to reduce skin resistance. In order to minimize disturbance, all cables were fixed and a wireless system of data transmission was used (Telemyo 2400T, Noraxon®). To identify touchdown an accelerometer was fixed at the lateral aspect of the calcaneus and to identify toeoff, a footswitch was fixed beneath the hallux.

Data Analysis: First, the signals of 10 steps without obvious artefacts were chosen and seperated from the EMG recordings for each subject and each of the three conditions. Second, the data were analysed using wavelet based software, which allows for simultaneously performing frequency, time and intensity analyses by transforming the signals into activity patterns (fig.1) (VonTscharner et al., 2003). Activity patterns were computed firstly for each subject. After a qualitative analysis of the computed activity patterns subjects were organized into different groups, in which subjects with similar activity patterns were collected. Then mean activity patterns were computed for the different groups.

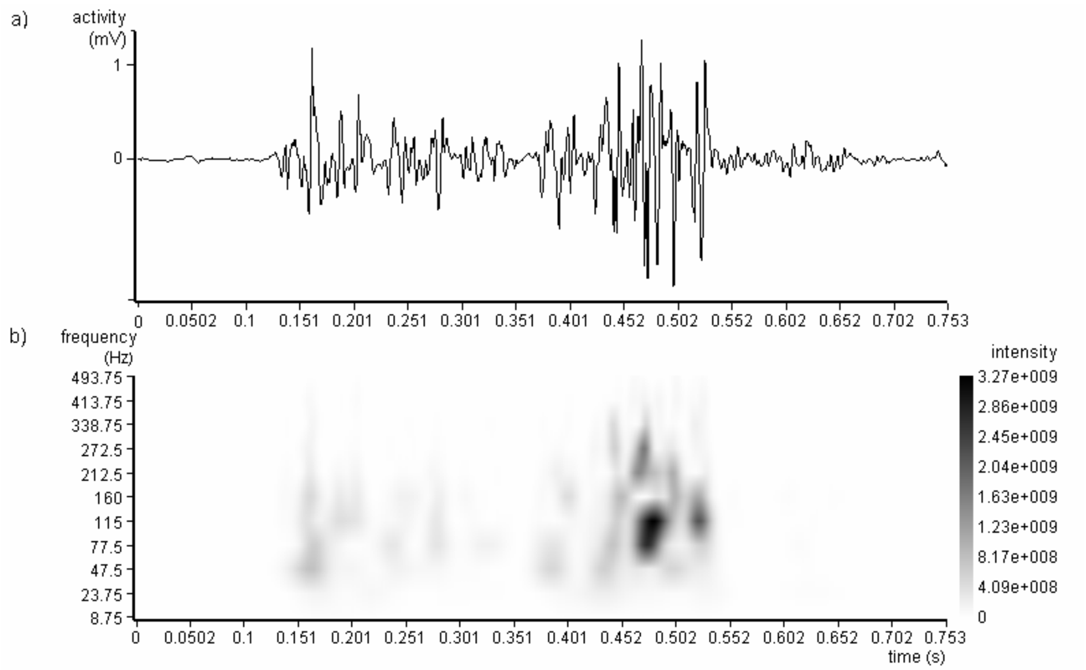

Figure 1: a) Recorded EMG signal of m. tibialis anterior (one step of running barefoot on tartan) and b) corresponding activity pattern. In activity pattern abscissa represents time, ordinate represents frequency and grey scale represents intensity of the recorded EMG signal.

RESULTS / DISCUSSION: The evaluation of activity patterns of m. tibialis anterior, m. semitendinosus and m. tensor fasciae latae revealed differences in muscle activation between the subjects. The electromyographic behaviour of these muscles was used to group the subjects into different groups (two groups for m. tibialis anterior, three groups for m. semitendinosus, two groups for m. tensor fasciae latae). There were systematic differences in activity patterns of several muscles between the groups. Especially activity patterns of m. tibialis anterior revealed conspicuous differences in muscle activation between the subjects for all three surface conditions (example for grouping in figure 2: Subjects in whose activity patterns of m. tibialis anterior appeared barely obvious intensity during stance were collected in group 1. Subjects in whose activity patterns of m. tibialis anterior occurred obvious intensity during stance were collected in group 2).

Systematic differences in muscle activation of several muscles between the groups refer to distinct movement behaviour, which gives reason to further studies with simultaneous kinematic / kinetic measurements.

Referring to all of the tested muscles there were differences in muscle activation between men and women. Different muscle activation patterns of men and women that were found in this study may be related to differences in body weight, connective tissue, anthropometry or dynamic segment alignment and refer to gender specific movement behaviour. Gender specific differences in movement are descibed (e.g. by Chappell et al., 2002). Ferber et al. (2003) considers gender specific injuries in connection with gender specific running mechanics. It seems to be advisable to examine the muscular activation in interconnection with kinetic / kinematic analyses to gather information about gender specific movement behaviour and thereby aroused loadings.

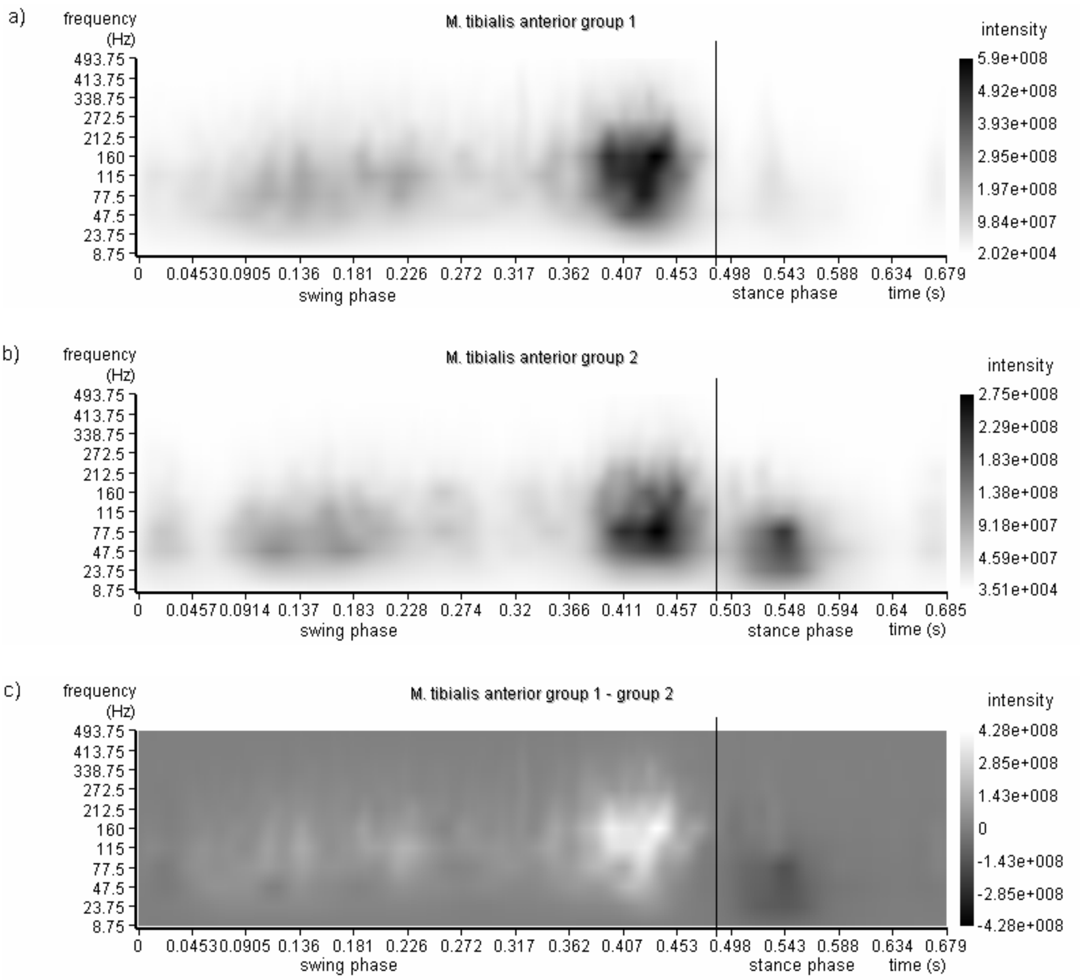

Figure 2: Activity pattern of m. tibialis anterior while running barefoot on tartan for different groups: a) group 1 (n = 21), b) group 2 (n = 18), c) difference of activity patterns of group 1 and group 2: light zones represent higher intensity in activity pattern of group 1, dark zones represent higher intensity in activity pattern of group 2.

Systematic increase or reduction of muscle activation of the tested muscles depending on running surface could not be detected. However, changes in muscle activity with changing surface could be identified: all subjects showed surface related changes in activity patterns. These changes were highly individual and muscle specific. On average the muscular response to surface changing was gender specific. Especially with regard to m. peroneus longus and m. vastus medialis the modification of muscle activation depending on surface condition was the opposite for men and women: for both muscles intensity in activity pattern of men was higher for running barefoot on grass than for running barefoot on tartan or shod. In contrast intensity in activity pattern of women was lowest for running barefoot on grass in comparison to running barefoot on tartan or shod for both m. peroneus longus and m. vastus medialis.

Gender specific muscular response to surface changes is to consider with respect to differences between muscle activation patterns of men and women. It may be also related to gender specific discrepancies in factors like e.g. body weight, connective tissue, anthropometry or dynamic segment alignment.

CONCLUSION: In this study surface related changes in muscular activation while running were investigated. Muscle activity pattern as well as muscular response to changing surfaces showed to be gender specific. Surface related changes in muscular activation were muscle specific. Further studies may treat a possible interaction between muscle activity and anthropometric / kinematic / kinetic data, which could lead to a deeper understanding of gender specific movement and may contribute to new findings concerning footwear design or injury genesis.

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