The influence of floor-surface hardness on muscle activation, coordination and fatigue during long-term static standing

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Introduction

From a work physiology standpoint it is well known that workers performing static standing work develop various symptoms ranging from muscle soreness, fatigue to severe pain from jounts and muscles. Overall, many workers have experienced that the floor surface hardness influences the development of symptoms. Soft surfaces seem to reduce the frequency of symptoms, and therefore most probably the development of chronic diseases (low back pain, etc.).

This writing introduces new methods that assess quantitatively the effect of hard and soft floor surfaces on muscle activation, muscle coordination and development of muscle fatigue during static standing. It has been well known for many years that the Electromyogram (EMG) can be used to assess those factors.

Two preliminary experiments were conducted. The first experiment investigated the change in muscle activation and coordination during static standing on hard and soft surfaces, and the second experiment investigated the development of muscle fatigue during toe standing on hard and soft surfaces.

Methods

<u>Experiment 1</u>

Volunteers (3 males) were standing in their bare feet for 30 min. on hard and soft (Ergomat (r), Holdan Pur, Denmark) surfaces. The sessions were conducted 24 hours apart with the volunteers reading a book when the experiment was carried out.

<u>Experiment 2</u>

Volunteers (3 males) were standing on their toes in their bare feet for 30 min. on hard and soft surfaces. The sessions were conducted 24 hours apart with the volunteers reading a book when the experiment was carried out.

EMG recording

The EMGs were recorded from the m. gastrocnemius medialis (calf muscle used when lifting the body during walking and during standing on your toes, also used to main stability) and m. tibialis anterior (used to rotate the foot upwards during walking, used to maintain stability during standing).

The skin was shaved and prepared with fine sandpaper and ethanol. Bipolar surface electrodes (Ag/AgCl electrode, area 0.25 cm2) with a 2 cm center-to-center distance were aligned along the muscle fibers. the EMG was pre-amplified ten times by small headstages (model 2010, Intronix Technologies, Ontario, Canada), transmitted to the amplifiers and filtered 20-450 Hz) before data acquisition (sampling rate 2024 Hz). Due to the pre-amplification, the EMG recordings were not affected by artefacts caused by e.g. moving cables. The EMG was full-wave rectified followed by second order low-pass filtering (cutoff frequency 3 Hz).

The RMS (root mean square) amplitude (corresponding to mean EMG activity level over a time interval) was calculated by the computer. The EMG signals were plotted as function of time for visual inspection. For each 10 seconds interval the RMS amplitude was calculated.

No statistical calculation can be made due to small sample size. After the experiment the subjects were asked to judge discomfort related to the experiment.

Results

Experiment 1

During standing the tibialis anterior showed different activation patterns depending on the hardness of the surface.

Standing on a hard surface the tibialis anterior was only occasionally active to maintain stability (fig. 1). Towards the end of the session the muscle increased the activity and substantial activity occurred (fig. 2).

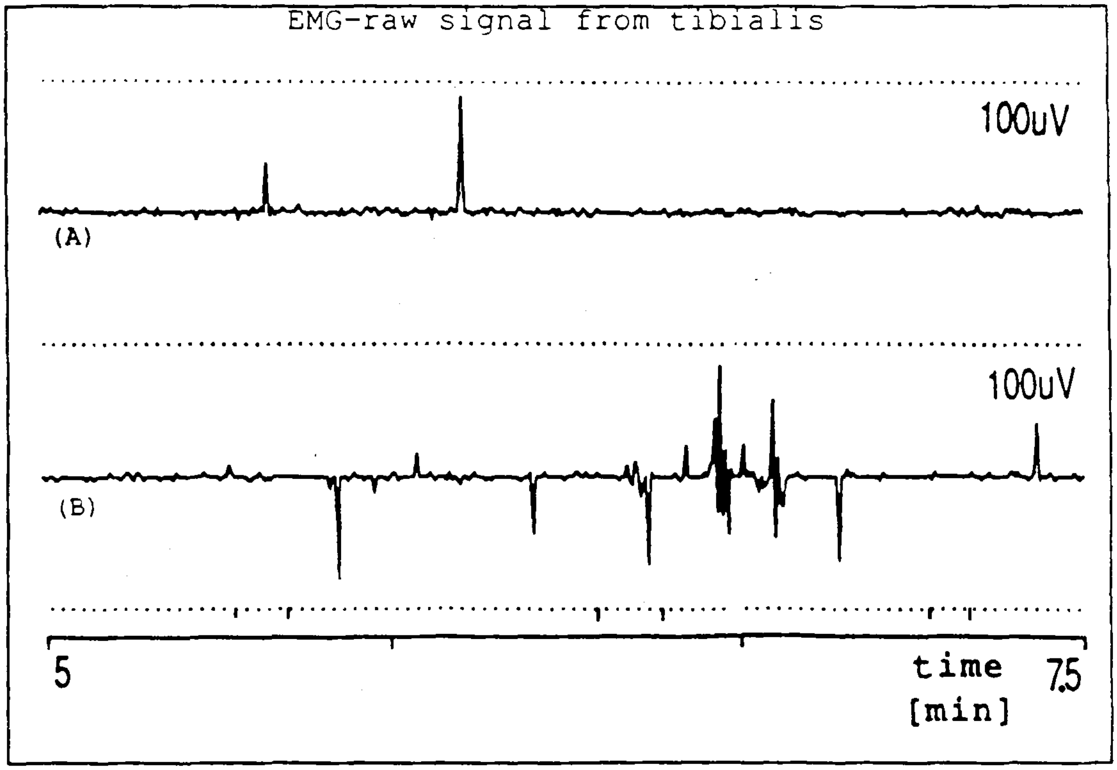

Figure 1. Raw EMG signals from tibialis anterior recorded from 5 to 7.5 min. after start of the experiment. A: standing on hard surface; B: standing on soft (Ergomat) surface.

Standing on a soft surface exactly the opposite pattern was found - the tibialis anterior was active to maintain stability in the beginning (fig. 1). When the subjects became used to standing on the soft surface the activity gradually reduced and only occasional spurious activity occurred to maintain stability (fig. 2).

This indicates that the transient activity at the beginning of the experiment when standing on a soft surface seems to result in a much better working condition for the muscle at the end of the experiment. This was supported by the subjects subjective report of substantially better comfort (less soreness, less fatigue sensation and less pain) when standing on soft surfaces.

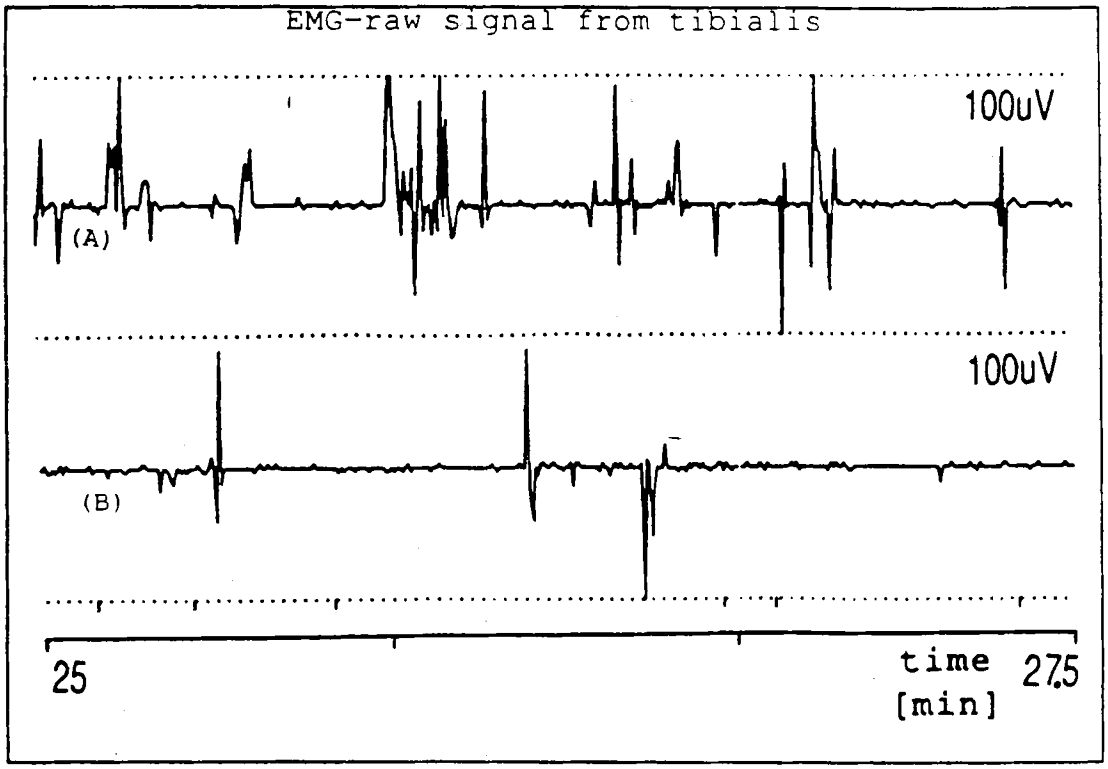

Figure 2. Raw EMG signals from the tibialis anterior recorded from 25 to 27.5 min. after start of the experiment. A: standing on hard surface; B: standing on soft (Ergomat) surface.

The activity in the gastrocnemius medialis was approximately 2 times higher when standing on the hard surface compared to the soft surface. This indicates that this muscle has to work harder on hard surfaces, which indicates a higher degree of strain on the lower limb muscles. This will also contribute to the development of fatigue symptoms. High muscle activation (approx. 40% of max. activation) is known to close the blood flow in the muscles (intramuscular ischemia). This is very important for development of fatigue.

Experiment 2

During this experiment, the RMS amplitude increased more when standing on a hard surface as compared with the soft surface (fig. 3). An increase in RMS has for many years been known to reflect development of fatigue in the muscle. Hard surface standing therefore does quantitatively fatigue the gastrocnemius medialis more as compared with soft surface standing. Again, the EMG findings corresponded with the subjective reports of a higher degree of comfort when standing on a soft surface.

From the fig. 3 we can also see that the subjects actually gave up after approx. 24 min. when standing on the hard surface.

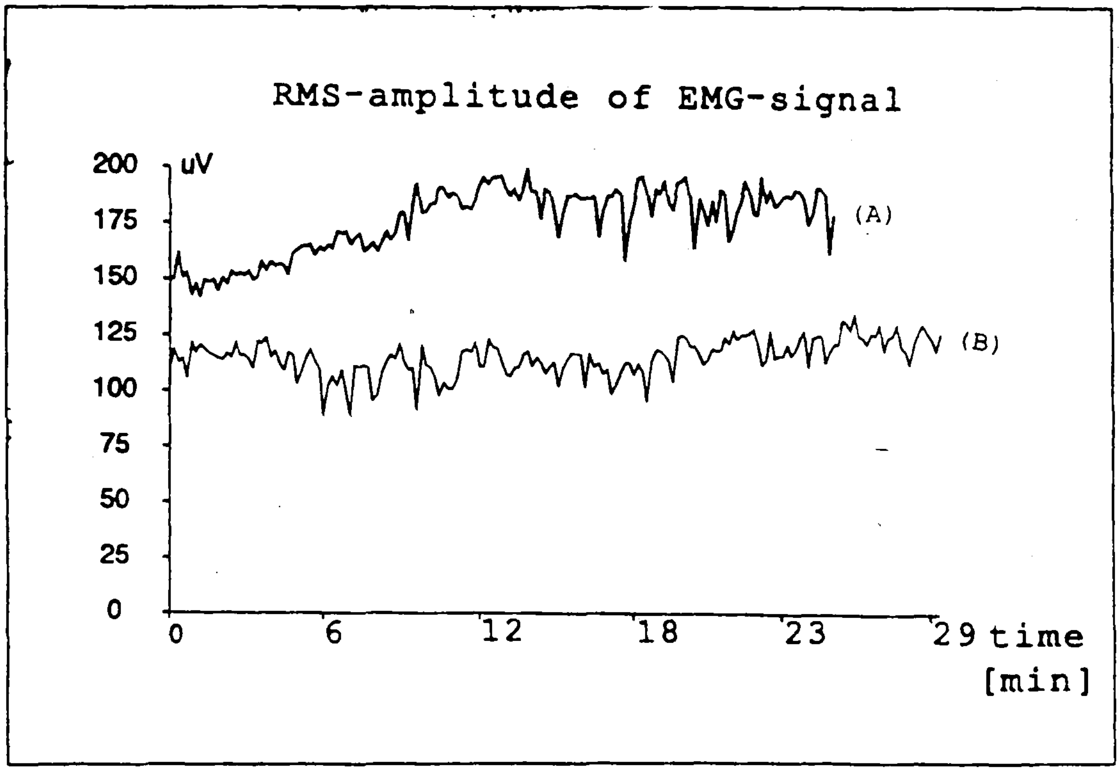

Figure 3. Development in RMS amplitude fra gastrocnemius medialis while standing on tiptoes on hard (a) and soft (b) surfaces. Increments in RMS indicate development of muscle fatigue. The initial RMS amplitude is higher when standing on a hard surface.

Conclusion

The present preliminary experiments do indicate that recordings of muscle activity can provide information how the muscles work and therefore compensate during standing on hard and soft surfaces. From a work physiological point of view this is very interesting as to date very few laboratories have developed sufficient sensitive techniques to assess changes in muscle status during static standing conditions.

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