PROLONGED STANDING AND THE EFFECT OF WORK SURFACE COMPRESSIBILITY ON DISCOMFORT, TIREDNESS, MUSCLE FATIGUE AND PRODUCTIVITY

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Abstract
This study investigated the effects and time course of work surface compressibility on body discomfort, tiredness, fatigue and productivity. Four university students were tested on each of three surfaces: a more compressible anti-fatigue mat (firm), a less compressible anti-fatigue mat (firmer) and a concrete floor (firmest - control). Each 120 minute test session required the subject to stand at ease in a 0.4m X 0.6 m area while playing a computer video game. Overall discomfort, perceived tiredness and productivity all showed the firm mat (more compressible) to be superior to the firmer mat (less compressible) which was superior to the concrete surface (least compressible). The time course for measurable change varied, depending on the dependant variable, from 15 minutes to one hour. Up to one hour of evaluation may be necessary by individuals using these products, or involved in the recommendation, in order to detect specific differences.

Keywords: Anti-fatigue matting, discomfort, EMG

LA STATION DEBOUT PROLONGÉE ET LES EFFETS DE LA COMPRESSIBILITÉ DE LA SURFACE DE TRAVAIL SUR LE CONFORT, LA FATIGABILITÉ, LA FATIGUE MUSCULAIRE ET LA PRODUCTIVITÉ

Résumé
Cette étude a exploré l'effet et la comprimabiliter d'une surface de travail sur l'aise corporelle, la fatigue et la production. Quatre étudiants ont joué un jeu vidéo pendant 120 minutes sur chacune des surfaces (0,4m X 0,6 m): un tapis comprimable anti-fatigue (ferme), un tapis moins comprimable anti-fatigue (plus ferme), et un plancher de béton. Les mesures d'aise corporelle, perception de fatigue, et production ont tous démontrées que le tapis ferme était supérieur au plus ferme, qui à sont tour était supérieur au béton. Le temps prise pour un changement marquable variai entre 15 minutes et une heure, dépendant de la mesure. Les individus impliqués dans l'évaluation ou la recommandation de ces produits requiront au moins une heure avant de remarquer des différences spécifique.

Mots clés : tapis anti-fatigue, inconfort, EMG

INTRODUCTION

Prolonged standing is often required for the completion of tasks in industry. To reduce the fatigue and discomfort associated with prolonged standing numerous types of anti-fatigue mats have been developed. More compensable mats have been hypothesized to stimulate Amuscle pump activity≅ and blood flow (2). Alternatively, a more compressible mat may increase the pressure on certain parts of the foot leading to localized discomfort and fatigue. Thus, a less compressible mat may be more beneficial (1). The purpose of this study was to investigate the both the effect and time course of work surface compressibility on body discomfort, tiredness, fatigue and productivity.

METHODS

Four moderately active university students (mean age 23 years) participated in this study. Each subject was tested on each of three surfaces: a more compressible anti-fatigue mat (firm), a less compressible anti-fatigue mat (firmer) and a concrete floor (firmest - control). Only one randomly ordered surface condition was tested per day. Each 120 minute test session required the subject to stand at ease in a 0.4m X 0.6 m area while playing a computer video game. Participants were allowed to shift their posture but were not permitted to lean or move outside of the outlined area. To eliminate the effect of footwear participants were required to wear a pair of thin cotton socks. At 0, 15, 45, 75 and 115 minutes subjects completed a 0 - 10 discomfort scale for each of 9 body regions (fore-, mid-, hind-foot, ankle, low-, mid-, upper-back, neck and head) (Corlett & Bishop, 1976). Subjects also evaluated their overall discomfort (0 - 10) and their perceived tiredness (0 - 10). At 15, 45, 75 and 115 minutes participants performed a penny inspection task which required the them to identify pennies in a specific decade and to successfully sort as many of them as possible in 2 minutes in an ascending, or descending order, as instructed. Mean power frequency (MnPF) analysis was performed on the raw electromyography (EMG) from the tibialis anterior (TA), gastrocnemius (GS) and the left and right erector spinae (LES, RES) muscles which was collected every 15 minutes using a portable data collection and analysis system (ME3000P, Mega Electronics Lt., Finland). The main effects of standing time and surface were analyzed using a repeated measures ANOVA for each of the dependant measures.

RESULTS

Body Region Discomfort Scores
Discomfort scores increased significantly from 0 in the fore-, mid-, and hind-foot body regions to 3.0, 2.7, and 2.7, respectively, as a function of the interaction between surface compressibility and standing time ($p < 0.03$). The anti-fatigue mats, which were not significantly different from each other, produced significantly less discomfort than the concrete surface. The increases in discomfort occurred within 15 minutes. The ankle and low back discomfort scores increased significantly from 0 to 1.3 and 1.7, respectively, as a function of time ($p < 0.005$) and it took 45 minutes for this effect to occur. This trend was also present, but not significant, for the low back ($p = 0.052$).

Overall Discomfort and Perceived Tiredness
Both overall discomfort and perceived tiredness increased significantly from 0 to 3.4 and 3.6, respectively, as a function of the interaction between surface compressibility and standing time ($p < 0.003$). For each of these factors the firm mat caused significantly less discomfort and tiredness than the firmer mat which produced significantly less discomfort than the

concrete surface. The time course for significant increases was 15 minutes and these scores continued to climb throughout the experiment.

Muscle Fatigue
The standing task produced significant reductions in MnPF in the TA, 80.1 % of initial frequency, after 45 minutes ($p < 0.0008$) and in the GS, 83.3% of initial frequency, after 90 minutes ($p < 0.0015$) regardless of the surface that the subject stood on.

Productivity
The penny sorting task was significantly affected by the interaction between surface compressibility and standing time ($p < 0.03$). The firm mat was associated with a significant increase in penny sorting over time, from 28 to 33 pennies correctly sorted in 2 minutes, while the firmer mat and concrete conditions had a decrease in successful penny sorting, from 31 to 23, and 26 to 19, respectively.

DISCUSSION

Several limitations in this study should be noted. The standing task was restricted to two hours. A longer duration may have lead to fatigue differences between surfaces. Subjects were also restricted to a small area and were not permitted to take a step. This scenario is more restrictive than typically observed in industry. Also, by testing the subjects in socks the effects of footwear is unknown.

A strong interaction of surface compressibility and standing duration was observed in the variables studied. Overall, the presence of anti-fatigue matting resulted in less discomfort, tiredness, fatigue compared to a concrete surface. However, standing duration was also shown to be a critical component. The time course for measurable change varied, depending on the dependant variable, from 15 minutes to one hour. Also, the compressibility of the surface was a significant factor. Overall discomfort, perceived tiredness and productivity all showed the firm mat (more compressible) to be superior to the firmer mat (less compressible) which was superior to the concrete surface (least compressible). The results of this research support the Amuscle pump activity≅ and blood flow hypothesis (2). Therefore, individuals using these products, or involved in the recommendation and/or selection of these products, need to be aware that depending on the compressibility of the anti-fatigue mat being evaluated, individuals may require up to an hour of evaluation before specific differences can be detected.

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